

## EXPERIENCES WITH POSTTRAUMATIC OSTEOMYELITIS IN WORLD WAR II

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OUR PURPOSE in presenting this material is to evaluate, insofar as is possible, our results in the treatment of osteomyelitis in Chinese battle casualties of the North Burma Campaign of 1943-1945. This is an elaboration and continuation of a report already published by Weeden and Stein.<sup>1</sup> Two factors must be first made clear: (1) Definition of osteomyelitis. (2) Method of interpreting end-results.

Chronic infection of the bone resulting from infected compound fractures as a result of trauma is not justly comparable to hemogenous osteomyelitis. The process is far less fulminating and its management proceeds along entirely different lines. Data for practical reporting or statistical analysis was collected from those case histories in which positive statements were recorded; *i.e.*, a roentgenologic diagnosis of osteomyelitis; a report by our pathologist on the nature of the operative specimens; or, a note by the operating surgeon that osteomyelitis or a sequestrum, or both, were encountered. Patients were managed by all of the surgeons in the hospital, and not segregated. Frequent observation and consultation by the Chief of the Surgical Service, however, tended to effect greater uniformity than this description suggests.

An accurate comparison of the results of treatment of the chronic osteomyelitis encountered in World Wars I and II is not intended. The supplementary use of the sulfonamides has encouraged present-day surgeons to attempt primary closures, and, in the opinion of many surgeons, has completely altered the management of the disease, from that encountered in the military hospitals during World War I.

Caldwell<sup>2</sup> has concluded that the pre- and postoperative use of sulfonamides is indicated when reconstruction of infected fractures is anticipated, because it reduces systemic and local diffusion of infection. However, elimination of local bone infection should not be anticipated. Our impressions justify this conclusion. Yet Dickson, Dendey and Kiene<sup>3</sup> reported a series of 22 patients in whom the osteomyelitis was treated by pre- and postoperative sulfathiazole, saucerization, wound closure, and immobilization, with complete healing occurring in 82 per cent of instances on an average of 23 days. Badgley and Harris<sup>4</sup> described a series of 25 case histories of old nonunited, infected fractures. In the presence of infection definite reconstructive procedures were performed. Wounds were left open, and 72 per cent of cases united and were healed on an average of 13 months. The

obvious difference in the healing period brings up the whole question of whether such wounds may be closed safely, now that the sulfonamides are available.

In 1944, Key<sup>5</sup> began the treatment (over a 2.5-year period) of 101 consecutive cases of osteomyelitis, administering sulfathiazole for five days pre- and 15 days postoperatively. The tibia was involved in 33 instances, the femur in 24, and other bones in 44. Including 11 amputations, 60, or 59.4 per cent, healed *per primam*. The reports are not classified as to the percentage of healing occurring in each bone studied, and the inclusion of amputations seems unwarranted.

Tourney<sup>6</sup> reported the cases of 13 patients very similarly managed, with healing in ten instances, or 76.8 per cent. The series is small, and a comparison of healing in upper and lower extremity lesions is, again, not reported.

That chronic infection, associated with retained sequestra or foreign bodies, is often sulfa-resistant, and that the debilitated status of many patients may contraindicate sulfonamide therapy was well-recognized by Lyons.<sup>7</sup> Both Speed<sup>8</sup> and Baker<sup>9</sup> concluded that the local use of sulfonamide is of help in combating infection, only when the fundamental rules of wound hygiene have been followed. Baker rightly asks what results might be obtained from adequate surgery without chemotherapy, because of the relative lack of improvement from the addition of sulfonamide to the open method. After a study of data gathered from the case histories of 2,191 patients, 674 compound fractures, Meleney<sup>10</sup> came to a conclusion somewhat similar to that of Speed and Baker.

In these patients the chief factors concerned with the development of infection were found to be as follows:

1. The degree and extent of tissue damage.
2. The degree of gross contamination by dirt and other foreign bodies.
3. Time-interval between injury and initiation of surgical care.
4. The nature of the bacterial contamination of the wound.
5. The care and thoroughness with which the devitalized tissue, foreign bodies and gross contamination were removed from the wound.

Meleney<sup>10</sup> could not demonstrate that sulfonamides, locally or systemically, materially reduced the incidence or severity of local infections, or eliminated the pathogenic organisms from the wounds. Spread of local infection was minimized, however, and hence the incidence of septicemia and death decreased, when the drug was administered by systemic means.

The bulk of the evidence, therefore, seems to force us to conclude that the addition of the sulfonamides to our armamentarium in the treatment of chronic osteomyelitis has had its greatest value when employed systemically, and acts in the following manner:

1. The disease remains as a localized process in the bone involved, instead of producing a fulminating and disseminating process.

2. Preoperative sulfonamide therapy will frequently decrease the infection of the adjacent soft tissues, and sometimes clear it up entirely.

Improvement and standardization of sound surgical principles are still of the greatest importance in the management of the local infection of soft tissues and bone.

The material upon which this report is based consisted of 365 Chinese soldiers, almost all of whom fought in the Hukawng and Mogaung Valleys, and between Myitkyina and Bhamo along the Irawaddy River in the North Burma campaign of 1943-1945. Whereas, they are a sturdy race, many of the soldiers were afflicted with chronic malnutrition, malaria, dysentery and venereal diseases. The recurrence of malaria after any operative procedure was quite frequent, and it is hard to believe that chronic diseases did not have some deleterious effect on wound healing.

TABLE I  
RESULTS

Bones	Total	Per Cent	Healed at 3 Months	Per Cent	Hosp. Av.	Full Duty	Per Cent	Limited Duty	Per Cent	Disab. Duty	Per Cent
Tibia.....	76	20.7	36	47.3	10.3	46	60.5	14	18.4	16	21.0
Femur.....	64	17.7	17	26.5	7.2	35	54.6	5	7.9	24	37.5
Humerus.....	50	13.6	21	42.0	6.4	27	54.0	11	22.0	12	24.0
Ulna.....	28	7.6	14	50.0	5.5	18	64.3	8	28.5	2	7.1
Radius.....	26	7.1	16	61.5	8.8	16	61.5	5	19.2	5	19.2
Phalanges.....	23	6.3	12	52.2	3.8	18	78.2	3	13.0	2	8.7
Metatarsals...	22	6.0	7	31.8	5.5	10	45.5	4	18.1	8	36.2
Pelvis.....	14	3.8	6	42.8	5.9	11	78.6			3	21.3
Ribs.....	13	3.5	7	53.9	5.1	10	76.9	1	7.7	2	15.4
Metacarpals..	12	3.3	9	75.0	4.5	11	91.6			1	8.3
Fibula.....	12	3.3	7	58.3	5.9	7	58.3			5	41.6
Os calcis.....	9	2.5	2	22.2	6.7	8	88.8			1	11.1
Scapula.....	8	2.2	4	50.0	3.8	5	62.5	2	25.0	1	12.5
Sternum.....	4	1.1	2	50.0	5.5	3	75.0			1	25.0
Carpals.....	4	1.1	3	75.0	8.3	3	75.0			1	25.0
Clavicle.....	3	0.8	2	66.7	6.0	2	66.6			1	33.3
Total.....	368	100.0	165	44.8	6.2	230	62.6	53	14.5	85	23.0

The diagnosis of osteomyelitis, as we have defined it elsewhere, was established in every instance by radiographic means, the presence of infected bone and marrow, or the removal of a sequestrum. Whereas, it might theoretically be advisable to divide our study into that of frank osteomyelitis and sequestration, for practical purposes the same disease exists in both instances. Hence, no attempt will be made to differentiate between the end-results of each, since the extrusion or removal of a single sequestrum by no means guarantees cure.

Although such information was not always found on the accompanying slips or charts, we presumed that all cases received débridement and encasement in the Portable Surgical Hospitals and Aid Stations in the Forward Area. Many of them must have been given a variable amount of one of the sulfonamides.

Osteomyelitis of the skull, jaws and vertebrae is not included in this study.

*Analysis.*—It is readily seen that the tibia is by far most commonly injured and involved by infection. Likewise, the healing period (10.3 months) from injury to discharge on duty status is considerably longer than that of the humerus (6.4 months), or femur (7.2 months). This is probably due to its subcutaneous position and often inadequate and compromised blood supply.

The bones of the forearm, particularly the radius, are seen to respond fairly well to surgery.

## REOPERATIONS REQUIRED

Radius.....	3.8%
Ulna.....	7.1%
Femur.....	18.7%
Tibia.....	26.3%
Humerus.....	16.0%

Here, again, the necessity for reoperations is seen to be far higher in the case of the lower extremity than in the upper.

*Primary Closure.*—When adequate soft tissue was available the closed method was applied to those cases. This type of wound management was employed in 69 instances. Patients were routinely given sulfonamide gr. 15

TABLE II  
RESULTS OF PRIMARY CLOSURES OF WOUNDS

Bone	No.	SUCCESES			Total	Failures	
		Healed	Prim.	Secondary			
Femur.....	9	2	22.2%	4	44.4%	4	66.6%
Tibia.....	16	9	56.2%	3	18.3%	12	74.5%
Humerus.....	12	8	66.6%	2	16.6%	10	83.4%
Radius.....	9	5	55.5%	3	33.3%	8	88.8%
Ulna.....	9	2	22.2%	4	44.4%	6	66.6%
Scapula.....	2	2	100.0%			2	100.0%
Phalanges.....	4	3	75.0%			3	75.0%
Carpal.....	3	3	100.0%			3	100.0%
Metacarpal.....	2	2	100.0%				
Pelvis.....	3	2	66.6%	1	33.3%	3	100.0%
Total.....	69	38	55.2%	17	24.6%	55	79.8%
						14	20.3%

four times daily for three to four preoperative and about seven to fifteen postoperative days. Plaster encasement was applied in all instances. A definite attempt was made to remove all infected tissue both soft and osseous. Wherever possible adjacent muscles were approximated closely to the defect and a pressure dressing applied. Our results in the case of these 69 patients were as follows:

Primary healing.....	38	55.2%
Secondary healing.....	17	24.6%
	55	79.8%
Failures.....	14	20.3%

The results of employment of primary closure was thus satisfactory in 79.8 per cent of patients so treated. As regards wound healing (Table II) the total length of hospitalization before return to duty status was not

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appreciably shortened (Table III), except in the case of those patients in whom the ulna alone was involved. The most significant advantage of the closed method lies in the fact that a definitely larger percentage of patients was returned to full duty (Table IV) when the femur, tibia or humerus were involved by osteomyelitis. Wounds of the forearm were complicated by injuries to numerous important adjacent structures to such an extent that a return to duty status was less frequently possible (Table V).

Three patients (0.82 per cent) died subsequent to operative treatment. One of these had far-advanced (Grade IV) pulmonary tuberculosis. His death occurred 12 days after total scapulectomy, at which time the operative

TABLE III  
COMPARISON OF HOSPITALISATION  
PRIMARY CLOSURES AND OPEN CASES

Bone	Primary	Open
Femur.....	7.2 months	7.5 months
Tibia.....	6.5 months	6.6 months
Humerus.....	5.2 months	5.7 months
Radius.....	8.2 months	7.8 months
Ulna.....	5.0 months	7.4 months

TABLE IV  
COMPARISON OF FULL DUTY STATUS  
PRIMARY AND SECONDARY METHODS

Bone	Total Cases	Cases to Duty	Closures (Primary)	Closures to Duty	% to Duty	Total Open	Open to Duty	% Open to Duty
Femur.....	64	35	9	8	88.8	55	27	49.0
Tibia.....	76	46	16	7	43.7	60	39	65.0
Humerus.....	50	27	12	7	58.3	38	20	52.6
Ulna.....	28	18	9	5	55.5	19	13	68.4
Radius.....	26	16	9	3	33.3	17	13	76.4

wound was clean. The two remaining deaths occurred in patients who had extensive osteomyelitis of the ribs. In each case the original trauma had involved intrathoracic organs, and the patients died of intrapleural infection.

### OPERATIVE MANAGEMENT

1. Because of extensive hemorrhage, whenever possible, a tourniquet was applied well proximal to the operative site, and extremely hot packs were available. Upon only a few occasions were pressure packs left in the wounds, and these were removed in two to three days.

2. Whenever curettage of the femur was contemplated, infusions of glucose or saline were started. Plasma was always available, but so great was the shock at times that transfusions of whole blood rapidly forced into the femoral vein were required. We are certain that this form of management prevented many accidents which might have cost the patient his life.

3. Strict adherence to the Orr-Trueta principle, as practised in the Forward Area, is not recommended in the Rear Echelon. Long periods of

immobilization often result in poor circulation of blood and lymph, skin damage, muscle atrophy and stiffness of joints. Wherever there was no danger of pathologic fracture, the plaster encasement was removed three weeks, postoperatively, and the wound treated by infrequent dressings. Earlier return of function resulted from this form of management.

Physiotherapy was often relatively ineffective as the individual soldier, because of pain, could not be convinced of the necessity of doing anything for himself in the way of active motion. As a consequence, many of the Chinese patients will not obtain the functional result expected in American patients.

TABLE V  
COMPLICATIONS

Bone	Nerve Lesion	Soft Tissue Lesion	Tendon Lesion	Muscle Lesion	Bone Graft	Poor Function	Pain-ful Gait	Pain-ful Scar	Ankyl-osis	De-formity	Others
Femur.....							2	2	Ankle 6 Knee 1		Nonunion 1 Hysteria 1
Tibia.....	Perineal 2				2	4		8	9		Hysteria 1
Fibula.....			1			3			1		
Metatarsals.....		2							2	2	Causalgia 1
Os calcis.....							4	1			
Pelvic bones.....							1				Pyarthro-sis 1
Scapula.....						1		1			TBC.
Clavicle.....											Causalgia 1
Sternum.....											Pyarthro-sis 1
Humerus.....	Radial 9 Median 1			3	3				9		Causalgia 2 TBC. 1
Radius.....	2	1	3		5				1		
Ulna.....	2	1	2		3				1		Cross-union 1 Lues 1
Carpals.....	1		3								
Metatarsals.....		1						3	1		
Phalanges.....		1			1	2			1		
Ribs.....											Pleural comp., and death (TBC.)2

#### SUMMARY

1. A report of 368 cases of osteomyelitis in Chinese soldiers is herein summarized.

2. The tibia is most frequently involved, followed by the femur and ulna.

3. Radical débridement of diseased soft and osseous tissue and good surgical toilet is imperative if a definitive arresting of the disease is to be attained.

4. Employment of sulfonamides systemically probably results in a more localized pathologic process, and, certainly, prevents dissemination of the disease. The rationale of local use of sulfonamides is doubted.

5. Primary closure is recommended in the management of osteomyelitis when adequate soft tissue is available. Otherwise, the open method is advocated.

6. Early removal of the plaster encasement is recommended where pathologic fracture is not apt to follow such management, to permit earlier recovery of skin, soft tissues, circulation and joints.

#### REFERENCES

- <sup>1</sup> Weeden, Willis M., and Stein, Hymen D.: Experiences with Injuries and Diseases of Bone in World War II. *ANNALS OF SURGERY*, **122**, 23, 1945.
- <sup>2</sup> Caldwell, Guy A.: Lectures on Reconstructive Surgery. American Academy of Orthopedic Surgeons, 1944.
- <sup>3</sup> Dickson, F. D., Dendey, R. L., and Kiene, R.: The Use of Sulfathiazole in Treatment of Subacute and Chronic Osteomyelitis. *Journal of Bone and Joint Surgery*, **23**, 516, 1941.
- <sup>4</sup> Badgley, C. E., and Harris, H. W.: Treatment of Ununited Infected Fractures. *Journal of International College of Surgeons*, **3**, 413, 1940.
- <sup>5</sup> Key, J. Albert: Sulphonamides in the Treatment of Chronic Osteomyelitis. *Journal of Bone and Joint Surgery*, **26**, 63, 1944.
- <sup>6</sup> Tourney, James W.: Sulphathiazone in Chronic Osteomyelitis. *Surgery*, **14**, 531, 1943.
- <sup>7</sup> Lyons, C.: The Evaluation of Sulpha Drugs. *Military Surgeon*, **95**, 301, 1944.
- <sup>8</sup> Speed, Kellogg: The Treatment of Open Fractures. *International Abstracts of Surgery*, **77**, 1, 1943.
- <sup>9</sup> Baker, L. D.: Sulfonamides in Traumatic and Infected Wounds. A Report of their Use in Fresh Compound Fractures, Old Compound Fractures, Fractures with Infection and Chronic Osteomyelitis. *Journal of Bone and Joint Surgery*, **24**, 641, 1942.
- <sup>10</sup> Meleney, Frank L.: Statistical Analysis of a Study of Prevention of Infection in Wounds, Compound Fractures, and Burns: With Special Reference to the Sulphonamides. *Surgery, Gynecology and Obstetrics*, **80**, 263, 1945.